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THE USE OF NONSHRINKING MORTAR FOR ANCHORING BOLTS IN CONCRETE MEMBERS

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At the request of the Bridge Division, an investigation has been made to determine the feasibility of using proprietary nonshrinking mortars to embed girder anchoring bolts in concrete bridge abutments. The material Embeco was specifically recommended for study by the Bridge Division but several other products were included in the investigation for comparative study. The other proprietary products considered were Sauereisen Iron Cement, X-Pando Pointing Mortar and Iron Bond.

Scope

The four proprietary products were tested and compared with ordinary 1:3 cement-sand mortar with regard to bond, compressive and tensile strengths. The bond test was used to give an indication of shrinkage of the grouting material and was performed by embedding standard square-head anchor bolts in 12-inch sections of 2-1/2 inch steel pipe and pulling out the bolts at the age of 7 days. Cement-sand mortar was placed both in the original condition as mixed and after preshrinking for 2-1/2 hours. In one case, the cement-sand mortar was placed as mixed and retamped around the bolts after 2-1/2 hours.

Summary

1. Cement-sand mortar proportioned one part cement to three parts sand, by weight, had highest bond strength in pull-out tests but showed noticeable shrinkage away from the boundary at the exposed surface. Both preshrunk and retamped mortars gave lower bond strength against the steel cylinder but shrinkage subsequent to placing was reduced. Iron Bond produced the lowest bond strength

with Embeco and X-Pando exhibiting intermediate values.

2. Sauereisen Iron Cement was worthless in these tests. When applied according to directions, it resulted in a weak, incoherent mass without strength of any kind.

3. Iron Bond addition resulted in the highest compressive strength - more than double that of plain cement-sand mortar. X-Pando gave the lowest compressive strength which was about 20 percent lower than that of plain cement-sand mortar.

4. There is a big difference in cost of the various grouting materials, the cost per cubic foot of grout ranging from about 35¢ for cement-sand mortar to $37.50 for Sauereisen Iron Cement.

Conclusions

Embeco is a satisfactory admixture for producing a non-shrinking mortar to seal anchor bolts in concrete.

The 7-day pull-out tests also indicate that a cement-sand mortar of 1:3 ratio would be satisfactory for the same purpose, provided that it was retamped about 2 to 3 hours after mixing and the plug boundaries sealed with asphalt cement. The only apparent objection to its use is the slight shrinkage crack that forms at the top boundary edge of the plug which might give trouble by permitting the entrance of water to cause progressive disintegration by freezing and thawing. Furthermore, it is not definitely known whether or not the plug would continue to shrink with time and eventually become loose in the hole. On the other hand, it would be the most economical and convenient material to use.

Test Procedure

1. Manufacturer's Recommended Proportions:

a. Embeco Nonshrink Grout. - Mix 100 pounds Embeco, 94 pounds normal cement and 1 cubic foot of clean sand to a uniform condition; then add water to make a placeable mix. Avoid an excess of water.

b. Sauereisen Iron Cement (a prepared mortar). - Mix 2 parts of Sauereisen Cement to 1 part of water.

c. X-Pando Pointing Mortar (a prepared mortar). - Add water to the dry mortar as received, until a workable consistency is reached.

d. Iron Bond. - Added to sand-cement mortar in proportions of 5 pounds of Iron Bond to 94 pounds of Portland cement and add water to a workable consistency.

e. Control Mortar. - 1 part cement to 3 parts sand, mixed to trowelling consistency.

2. Preparation of Test Molds. - Metal pipe, 2-1/2 inch inside diameter, was cut into 12-inch lengths and threaded. A coupling was sawed in two to form a bearing surface when screwed to the pipe sections. See Figure 1.

3. Preparation of Anchor Bolts. - 1-inch by 18-inch square-head anchor bolts were centered in the pipe sections on a flat surface.

4. Molding. - The mixed mortars were added in thin layers around the anchor bolts in the pipe sections and thoroughly tamped. The molds were tapped on the sides to assist consolidation. Three specimens of each mortar were made, except the control mortar. The control mortar was added to 9 molds. The first three were left undisturbed after molding. The second three were retamped and consolidated after 2-1/2 hours. The third three were not filled until the mortar had stood undisturbed 2-1/2 hours in the

mixing pan. Then the mortar was remixed without additional water and tamped into the molds. This was to provide a preshrunk mortar, The undisturbed cement-sand mortar exhibited a marked shrinkage during the first 2 or 3 hours of setting. The non-shrink mortars actually appeared to swell slightly during the setting period.

5. Curing. - After molding, the samples were stored in a moist room for 6 days; then removed to dry one day before test.

6. Compression Tests. - 2-inch cubes, prepared according to ASTM mortar specifications, were molded for compressive tests. These were cured 7 days in the moist room before testing.

7. Tension Tests. - Mortar briquettes of the non-shrink mortars only were prepared according to ASTM methods and cured 7 days in the moist room before testing.

8. Testing for Pull-out Strength.

a. A heavy coupling was threaded onto the anchor bolt and connected to an extension made of an anchor bolt with the head removed. The pipe coupling was threaded to the pipe mold and the whole inverted over a heavy plate bored to allow the core to pull through. These parts are shown in Figure 1. A pulled sample is also shown.

b. The assembly was tested in a testing machine as shown in Figure 2. Tension was applied until a failure occurred either by bond to the pipe or by bond to the bolt. Indication of failure was shown by a sudden drop of the testing machine weigh beams.

Results

1. Pull-out Tests. - Table I

a. Cement-Sand Mortar.

1). The undisturbed mortar series provided 337 pounds unit bond strength in pull-out, which was the highest of any of the mortars tested.

2). The retamped mortar series provided 251 pounds unit bond strength in pull-out.

3). The remixed mortar series provided 226 pounds unit bond strength in pull-out.

4). The advantage of using a preshrunk mortar, even though of lower bond strength, is assumed to lie in the resistance to water infiltration around the core.

b. X-Pando. - This mortar failed through crushing of bolt head through the mortar. No slippage occurred between mortar and mold, therefore the results tabulated in Table I indicate only the average for the load applied to crush the bolt head through the mortar. The unit average stress at this load was 251 pounds per square inch. This was the highest bond strength of any of the non-shrinking mortars.

c. Embeco. - This mortar developed 243 pounds of unit bond strength and was second highest of the non-shrinking mortars.

d. Iron Bond. - This mortar developed 156 pounds of unit bond strength and was the lowest obtained strength of the non-shrinking mortars.

e. Sauereisen. - Two separate attempts were made with this mortar but no measurable strength was obtained. In one case, the manufacturer's recommended proportions were used and, in the other case, a drier consistency was used. Both failed to harden except on the exposed top and bottom surface for a depth of 1/4 inch to 1/2 inch. Free water remained in the interior of the specimen and the mortar was soft and pliable. After two weeks time, the mortar still remained soft and, upon removing from the mold, it rapidly heated up to temperatures just bearable to touch. This seemed to indicate improper curing, incomplete hydra- or other imperfection not clearly discernible.

Precautions in Use

1. X-Pando. - Do not use X-Pando Pointing Mortar in contact with cinders at grade level nor on masonry where toal tar water-proofings have previously been applied. Keep tightly sealed in can.

2. Embeco. - Accurate proportioning of mix is important. Avoid an excess of water. Hardens rapidly when container has once been opened, according to a local dealer's statement.

3. Sauereisen. - The literature does not give precautions in use, therefore, it is understood that normal care be given to keep dry and covered while not in use.

4. Iron Bond. - The same statement applies for Iron Bond as for Sauereisen.

Materials

1. Embeco Nonshrink Grout. - Master Builders Company, Cleveland Ohio. Obtainable in 100-pound containers at $20.00 per 100 pounds.

2. Sauereisen Iron Cement. - Sauereisen Cements Company, Pittsburg, Pennsylvania. Obtainable in gallons at $5.01 per gallon.

3. X-Pando Pointing Mortar. - X-Pando Corporation, Long Island City, New York. Obtainable in 10, 25, 50 and 100-pound lots at the rate of 20, 16, 14 and 12-1/2 cents per pound respectively.

4. Iron Bond. - Iron Bond Products, Detroit, Michigan. Obtain-

able at $185.00 per ton in 100-pound containers.

5. Control Mortar. - Portland cement - natural sand.

TABLE I.

SUMMARY OF TEST DATA

Mortar	Bond Strength 7 days psi.	Compressive Strength 7 days psi.	Tensile Strength 7 days psi.	Approx. Cost per cu. ft. of grout
1:3 Cement-Sand	338	4120		
	332	3831		
	341	3188		
Average	337	3713		$0.35
1:3 Cement-Sand (retamped after 2-1/2 hours)	324			
	205			
	223			
Average	251			$0.35
1:3 Cement-Sand (remixed after 2-1/2 hours)	216			
	241			
	221			
Average	226			$0.35
X-Pando	256*	2740	398	
	247*	3160	340	
	251*	2890	397	
Average	251	2930	378	$12.50
Embeco	245	6480	463	
	247	5910	423	
	237	7380	438	
Average	243	6590	441	$7.00
Iron Bond	140	9250	540	
	166	9050	550	
	162	9070	566	
Average	156	9120	552	$0.50
Sauereisen	Two separate trials were made but no strength developed in 7 days.			$37.50

* Failed in bolt-core bond. No slippage occurred between core and mold.

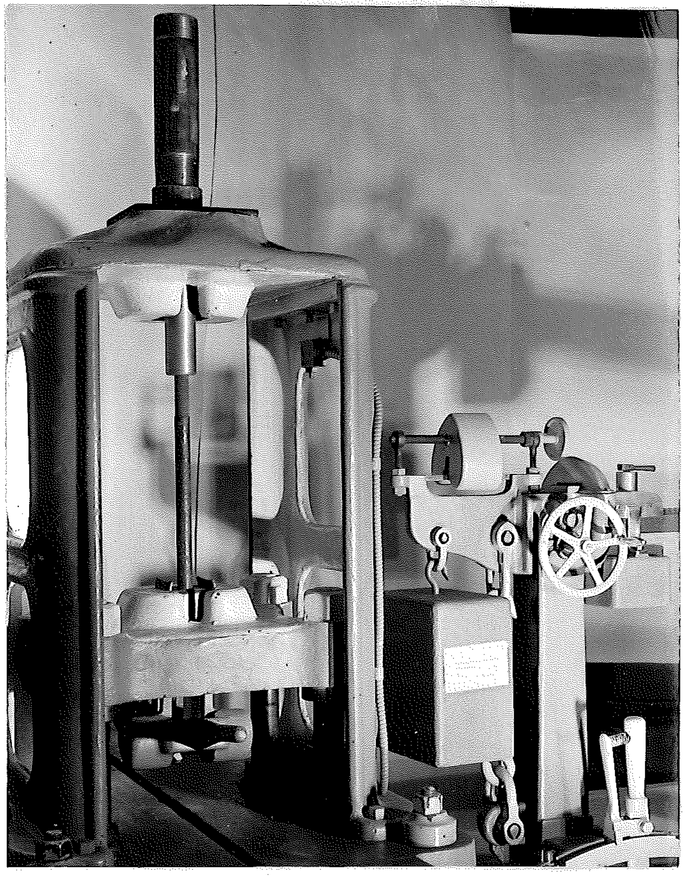

Figure 1. Method of determining bond strength.

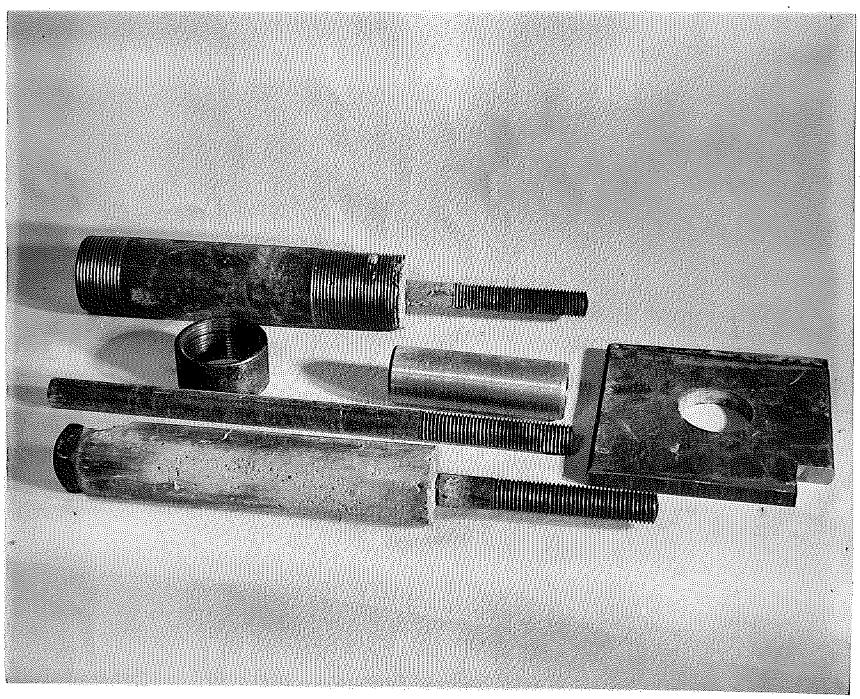

Figure 2. Test Assembly